DOCKET NO.: 215159US2PCT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: Simon POWELL

SERIAL NO.: NEW U.S. PCT APPLICATION

FILED: HEREWITH

INTERNATIONAL APPLICATION NO.: PCT/GB00/01508

INTERNATIONAL FILING DATE: 18 April 2000

FOR: ACTIVE MATERIAL LOW POWER ELECTRICAL SWITCHING MECHANISM AND DRIVE CIRCUIT THEREFOR

REQUEST FOR PRIORITY UNDER 35 U.S.C. 119 AND THE INTERNATIONAL CONVENTION

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In the matter of the above-identified application for patent, notice is hereby given that the applicant claims as priority:

COUNTRY	APPLICATION NO.	DAY/MONTH/YEAR
Great Britain	9908930.2	19 April 1999

A certified copy of the corresponding Convention application(s) was submitted to the International Bureau in PCT Application No. **PCT/GB00/01508.**

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Marvin J. Spivak
Attorney of Record
Registration No. 24,913
Surinder Sachar
Registration No. 34,423

22850

(703) 413-3000
Fax No. (703) 413-2220
(OSMMN 1/97)

DOCKET NO.: 215159US2PCT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: Simon POWELL

SERIAL NUMBER: NEW U.S. PCT APPLICATION (based on PCT/GB00/01508)

FILED: HEREWITH

FOR: ACTIVE MATERIAL LOW POWER ELECTRICAL SWITCHING MECHANISM AND DRIVE CIRCUIT THEREFOR

REQUEST FOR CONSIDERATION OF DOCUMENTS CITED IN INTERNATIONAL SEARCH REPORT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In the matter of the above-identified application for patent, notice is hereby given that applicant(s) request that the Examiner consider the documents cited in the International Search Report according to MPEP §609 and so indicate by a statement in the first Office Action that the information has been considered. When the Form PCT/DO/EO/903 indicates both the search report and copies of the documents are present in the national stage file, there is no requirement for the applicant(s) to submit them (1156 O.G. 91 November 23, 1993).

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Marvin J. Spivak
Attorney of Record
Registration No. 24,913
Surinder Sachar
Attorney of Record
Registration No. 34,423

22850

(703) 413-3000
Fax No. (703) 413-2220
(OSMMN 1/97)

PCT/GB00/01508

09/926352

GB00/1508

4

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 22nd May 2000

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Patents Form 1/77

Patents Act 19[illegible]
[illegible] 16)

The Patent Office

1/77

20APR99 E441054-5 D00180
P01/7700 0.00 - 9908930.2

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

19 APR 1999

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

ABC /B

2. Patent application number
(The Patent Office will fill in this part)

9908930.2

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

PBT (IP) Limited
1 Astra Centre
Edinburgh Way
Harlow
Essex CM20 2BN

Patents ADP number *(if you know it)*

7597313001

If the applicant is a corporate body, give the country/state of its incorporation

A British company

4. Title of the invention

Active Material Low Power Electrical Switching Mechanism

5. Name of your agent *(if you have one)*

A. A. THORNTON & CO.

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Northumberland House,
303 - 306 High Holborn,
London WC1V 7LE

Patents ADP number *(if you know it)*

75001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	-
Abstract	-
Drawing(s)	1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date

A. A. THORNTON & CO. 19 April 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr Andrew Crawford - 0171 405 4044

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

ACTIVE MATERIAL LOW POWER ELECTRICAL SWITCHING MECHANISM

The present invention relates to an electrical switching mechanisms and more particularly to such mechanisms when used in electrical safety equipment such as residual current circuit breakers.

In our earlier international application WO-A-98/40917, we have disclosed a novel form of electrically activated mechanical release mechanism which we have turned an actuator which improves the displacement behaviour of active material benders using materials such as piezo-ceramics. A feature of all active materials is that they are relatively inefficient, having coupling factors between the driving means and the output of fractions of a percent. Consequently, actuators which use such materials tend to require high fields be they magnetic or electric. However, we have found that despite this disadvantage, an actuator utilising an active material bender can result in a product having good mechanical properties.

The area of interest in this invention is the field of Residual Current Devices, known as RCDs. This term covers Residual Current Circuit Breakers which are not equipped with current limiting capabilities and Residual Current Breakers with Overload which have current limiting portions.

RCDs function by comparing the current flowing within the live and neutral conductors, on the principle that it should be equal and opposite. A variation in the currents indicates a leakage from the circuit which is usually indicative of a fire risk or a human in danger of electrocution.

RCDs are manufactured in many formats, such as adaptors, plugs, electric socket outlets and consumer unit devices. In performance terms, devices can be divided into two specific types.

Line Dependent devices use electronic processing to measure the differential current and to then trigger an actuator that causes the circuit to be

opened. These devices benefit from being flexible and consistent, because their trip level can be set by the selection of threshold resistors, and the tripping action is not reliant upon the energy within the fault, as the electronics can call upon the mains supply to power the actuator.

Line independent devices utilise the energy from the fault itself to initiate the tripping action. This is most commonly achieved through the use of a permanent magnet relay. The principles of permanent relays are well-known, but to summarise a movable metal part is held in a first position by means of a suitable permanent magnet which is surrounded by a coil. When a fault current flows it induces a current within a toroidal transformer connected to the coil surrounding the magnet. The current flow is rectified such that its associated magnetic field opposes that of the permanent magnet until the movable piece is freed. In order to make highly sensitive relays the mating surfaces of the metal parts must be of exceptional flatness, and the system must be totally clean. The flattening and assembly processes are consequently expensive.

Our International Application WO98/40917 discloses a novel form of actuator suited to active materials, termed a planar bimorph. The same application also discloses a methodology for using such actuators to release mechanisms. Such systems require a large voltage in order to operate, and such voltages cannot presently be generated in line independent systems.

It is an object of the present invention to provide an electrical switching mechanism utilising an active material bender which is driven by an inductive circuit where output is converted into a high voltage.

Preferably, the mechanism includes an active material bender as disclosed in our earlier international application no. WO98/40917.

In order that the present invention be more readily understood, an embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 shows an exploded perspective view of a release mechanism

which can be used as the basis of the present invention; and

Fig. 2 is a circuit diagram of the drive circuit for the mechanisms shown in Fig. 1.

The switching mechanism of the present invention comprises a release mechanism and a drive circuit.

The electrically actuable mechanical release mechanisms shown in the accompanying drawings and is constructed from a number of layers of sheet material. The relative thicknesses of the different layers are chosen having regard to the different functions to be performed by the layers and this also applies to the material utilised. For ease of handling in this particular construction, the material is metal strip in which the thickness is readily controlled to acceptable limits by the fabrication process. Thicknesses of 0.15 millimetres to 0.2 millimetres have been found to be suitable but other thicknesses can be used as can other materials for certain of the layers. It is not necessary for the layers to be metal or conductive and in fact, in some instances it may well be an advantage for the layers to be insulative or self lubricating by being manufactured from a suitable plastics material.

The mechanism comprises are substrate 10 to which are attached a stack of other layers the stack comprising a frame 12 a spacer 14 and a planar bimorph layer 16 a slider element 18 is arranged to slide within a profiled channel 30 formed in the frame 12 and the slider is formed with an extension 32 which extends beyond the open end of the profile channel 30 in the frame 12.

The slider 18 is formed with a slot 34 which is arranged to receive a spring 36 with one end of the spring being located on a spring seat 37 with the other end of the spring 36 in engagement with a spring seat 38 provided on one of the other layers, in this case the spacer layer 14. The slider member is capable of being latched against the action of the spring 36 by means of a rotatable pawl 40. The pawl 40 is mounted for rotation by means of a bearing 41 provided in the spacer 14, the spacer also being provided with an actuator 42 through which the

operable, movable tip 44 of the piezo bimorph extends in order to control the rotation of the pole 40 and thus the release or latching of the slider 18.

Before describing the operation of the above described mechanism, it is important to understand that the profiled channel 30 in the frame 12 is specially shaped so that the slider 18 although being largely movable linearly under the action of the spring 36 is also capable of slight lateral or rotational motion. Also, the profiled channel narrows near the open end of the channel so as to restrict the stroke of the slider which is formed with protrusions 46. Also, the pawl 40 has a semi circular portion 48 arranged to be received in a corresponding portion 50 of the profile channel so as to be capable of angular movement in the direction of the arrow A within the profile channel. The pawl is formed with a shaped recess 52 arranged to receive a projection 54 on the end of the slider 18 remote from the spring 36 the shape and size of the meeting projection 54 and recess 52 are carefully designed to provide a specific burst force and the slider is also provided with additional.

Turning now to the operation of the mechanism, let us assume that the various layers are all assembled, stacked one on top of the other with the slider in position in the channel 30 such that a latching surface 56 is in engagement with a latching surface 58 on the frame 12 and the spring 36 is thus in compression between the spring seats 37 and 38. The surfaces 56 and 58 are angled such that the spring force is converted into a rotational force as indicated by the arrow B. This rotation is restricted by virtue of the projection 54 on the slider 18 being restrained by the recess 52 in the pawl 40. Movement of the pawl 40 in the direction of the arrow A is restricted by virtue of the moveable end 44 of the piezo bimorph 16. The operating end of the bimorph is formed with a pen like member which is the depth of the spacer 14 and the slider 18 and this is typically 0.35mm.

When the mechanism is to be actuated, an electrical signal is applied to the piezo bimorph 16 which causes the bimorph to flex in such a way that the pin 44 is pulled upwards, out of the plan of the paper, and out of an engagement

with the pole 40. The shape of the meeting surfaces of the projection 54 and recess 52 in combination with the shape of the meeting surfaces 56 and 58 under the action of the force exerted by the spring 36 causes the slider 18 to start to pivot in the direction of the arrow B which in turn forces the pole 40 to rotate in the direction of the arrow A until such time as the pole 40 releases the projection 54 which permits free movement of the slider 18 firstly in an arcuate direction in the direction of the arrow B and subsequently in the direction of the arrow X so that the tip 32 of the slider 18 can be used to activate a further mechanism or apparatus.

In order to reset and relatch the mechanism, it is assumed that there is no electric signal applied to the bimorph 44 so that the pin 44 is in its down most position. By moving the slider 18 in the direction opposite to the direction 8, the spring 36 is compressed and the slider is moved past the latching projection 58 to permit the projection 54 on the end of the slider to be received in the recess 52 in the pawl. The pawl is rezilulantly bias by a slight spring force in a direction opposite to the direction of the arrow A so as to permit the projection 54 to be captured by the recess and the pin 44 to hold the capture position.

It will be appreciated that the above construction is capable being manufactured to any dimensions. In fact, it is very suitable for micro-machining techniques due to the laminar nature of the structure.

Due to the small engagement depth and release force, it is possible to explicit the large motion of the planar bimorph to create a system which operates from a low voltage. A suitable drive circuit for such use will now be described with reference to Fig. 2.

In this embodiment, the sensing means on an RCD is a toroidal transformer 60 which comprises a right turn from the mains line and a number of secondary turns, typically 1000 or more, on the secondary. High permeability materials such as Nickel Iron are used to increase the overall inductance of the system.

The voltage created in the secondary of such a toroidal transformer

is the back emf to oppose any change in the primary. Under normal circumstances the current flowing in the live and neutral are equal and opposite, so the magnetic fields cancel out. If a proportion of the incoming current begins to flow out of the circuit the fields cease to be equal and opposite, resulting in an induced voltage in the secondary. Initially, the induced waveform is sinusoidal, to match the fault current, but as the fault current increases the toroidal transformer saturates and the output wave form becomes spiked. In traditional electro-mechanical relays this is a disadvantage, because the power delivered decreases.. Piezo electric and electrostrictive materials however are distinctive in being very low power but demanding of an electric field in order to operate. The voltage output of an inductor is calculated by the equation E=-L di/dt, where E is the Voltage, L is the system inductance and di/dt is the rate of change of current over time. The saturation of the magnetic core results in a very di/dt and so the voltage goes up. The present invention utilizes this behaviour in order to generate an initially high voltage from the toroidal transformer which is designed to substrate at a point around 50% of the trip value.

The output of the toroidal transformer is then fed to a voltage multiplier circuit 61 where the voltage is doubled or tripled using any suitable circuitry.

The voltage multiplier circuit 61 is then used to drive a piezo ceramic bender such as the one shown in Fig. 1 to then release the contacts 63 of the device.

This arrangement then constitutes a particularly effective low-power line independent device.

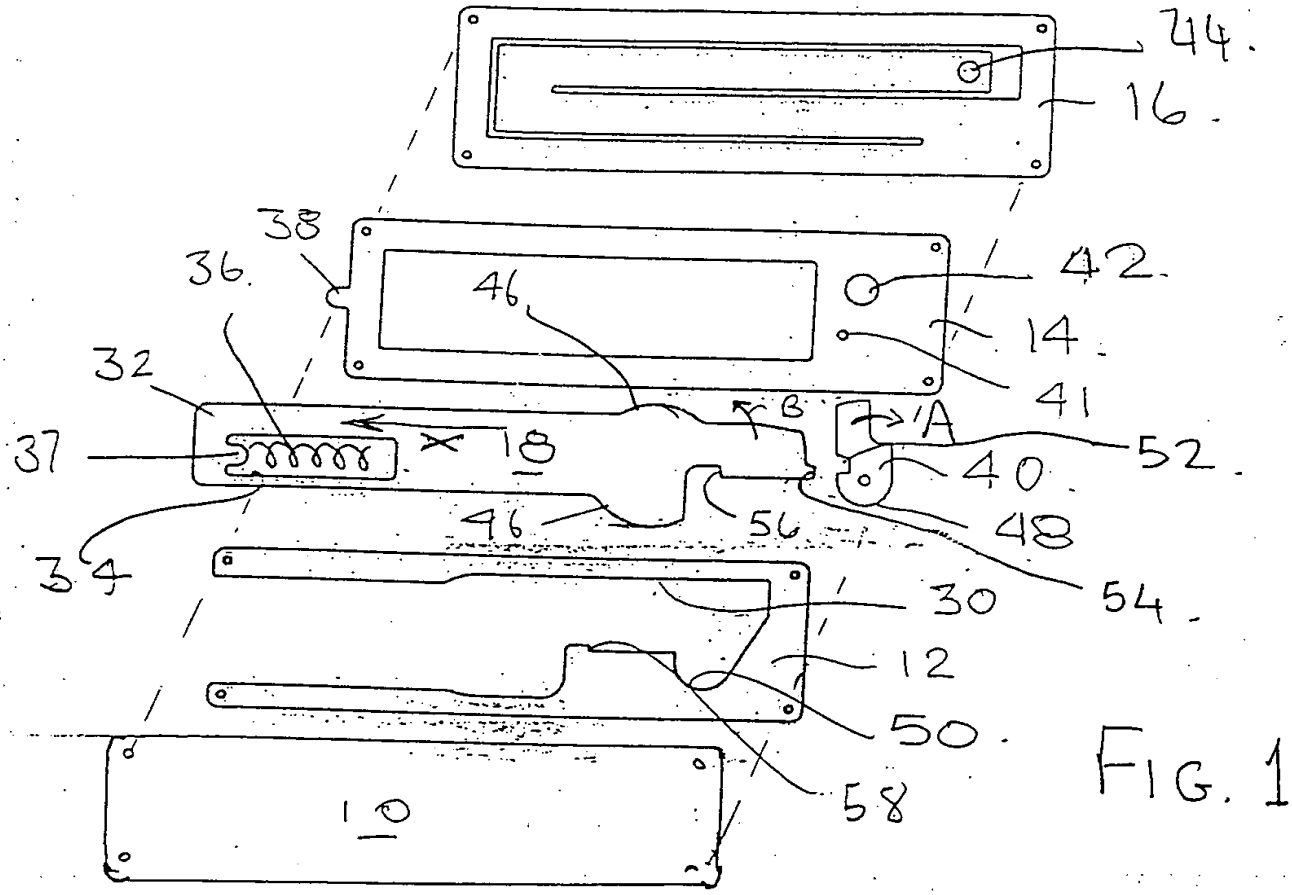
44
16
38
36
46
42
14
41
32
B
A
37
18
52
40
46
56
48
34
54
30
12
50
58
10

FIG. 1

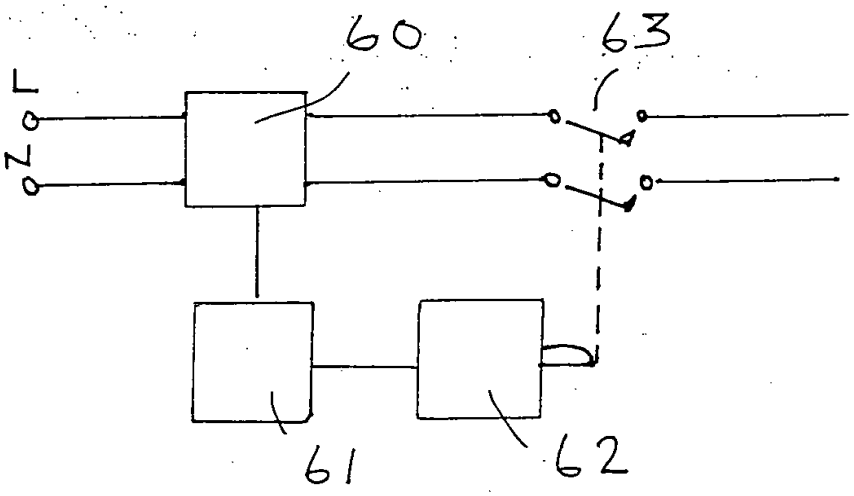
60
63
L
N
61
62

FIG. 2

PCT/EB00/01508

A A. Thornton & Co

filed 16/5/00

THIS PAGE BLANK (USPTO)